MISSOURI DEPARTMENT OF NATURAL RESOURCES

CLEANUP LEVELS FOR MISSOURI (CALM) Appendix H

Examples

Division of Air and Land Protection
Hazardous Waste Program

Revised September, 1998

CLEANUP LEVELS FOR MISSOURI (CALM)

APPENDIX H - CALM EXAMPLES

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1. INTRODUCTION

The following three examples were prepared to illustrate how the CALM process might work in some situations. An effort was made to highlight the features of the CALM process expected to be most commonly used. Because of the nearly infinite permutations that are possible in using CALM with real-world sites however, it is not practical to provide examples which cover all or even most of the possible uses of the document. The department encourages anyone considering entering property into the Voluntary Cleanup Program to contact the staff and discuss how CALM might apply in specific instances.

The simplified examples here may appear to suggest a certain standard sequence of events. They are presented in this format for convenience only. The actual sequence of events may differ significantly from these examples. For example, the department expects that many aspects of CALM evaluation will be conducted simultaneously, or at least iteratively.

2. EXAMPLE SITE A: PLATE-N-STUFF, INC.

2.1 Background & History

The subject site was operated as a metal plating and manufacturing facility since the 1890s. The plating company, Plate-N-Stuff, re-located in the 1960s, and after a series of subsequent lessees, the 2 acre site has been vacant since 1985. The site is now blighted, and surrounded mostly by other abandoned, former heavy industrial parcels.

Redevelopment interests in the area have increased, and a developer purchased property from the former owner to clean up and re-use as a residential development. The developer is negotiating contracts with several potential lessees, and is interested in starting redevelopment within months.

2.2 Environmental Conditions

As part of performing due diligence prior to the purchase, the developer contracted to have an environmental assessment conducted. Results of the assessment indicated that, based on a review of the historical records of past land uses, heavy metal contamination may be present at the site. Additional site assessment was conducted including the collection and analysis of soil samples. Contamination was detected from 2-10 feet below ground surface in one area of the site where plating wastes were believed to have been deposited. Contaminants included the heavy metals cadmium (Cd), chromium (Cr), and nickel (Ni). Polychlorinated biphenyls (PCBs) were also present in soils near the former location of an electrical transformer.

The developer enrolled the site in the Voluntary Cleanup Program in order to receive

guidance and oversight for the further assessment and possible remediation of the property, and to reduce their future environmental liability by receiving a certification of completion from the department.

With guidance from VCP, the developer's consultant conducted additional environmental investigation. The extent of soil contamination was defined based on additional soil sampling results. A map of the site indicating the locations of soil borings and monitoring wells is shown in Figure H1. Due to the elevated levels of contaminants in unsaturated soils, monitoring wells were installed and sampled to assess the potential migration of contaminants from soils to groundwater. Groundwater contamination was detected beneath the site, however the extent and concentration was minor. Data and supporting information was collected for use in the qualitative ecological exposure assessment.

The near-surface geology and hydrogeology of the site is relatively uncomplicated. The site is underlain by approximately 20 feet of soil which is fairly uniform, silty clay. The ground surface elevation does not vary much across the site. Shallow groundwater occurs approximately 15 feet below ground surface within the silty clay. Limestone bedrock was encountered below the soil, and based on regional geology data, is believed to extend from approximately 20 to 60 feet below ground surface, where a shale layer is present.

2.3 CALM Evaluation

Once the site had been characterized to the satisfaction of both the participant and VCP, the results were evaluated under CALM to assess contaminant levels found on the site, and evaluate the need for remediation. The site was also evaluated using the process described in Appendix F for ecological exposure assessment. Based on the information collected during the site assessment/characterization, ecological receptors were not present at or near the site which could come into contact with the released contaminants (the answers to all questions in Figure F2 of Appendix F were "no"). Further ecological assessment was therefore not conducted.

Since the intended future land use included residential, land use scenario A was selected. The Tier 1 soil and target concentrations were identified using the Scenario A, C_{IDI} and C_{LEACH} columns of Table B1 in Appendix B. The soil contaminant levels found at the site were compared to the STARC values as shown in Table H1 below. Results from several of the boring locations showed contaminant levels above the soil target concentrations. Cadmium was present in borings B2, B3, B9, and B10 above both the C_{IDI} and C_{LEACH} target concentrations. Chromium was detected above the C_{LEACH} in borings B2, B3, and B9, and above both the C_{LEACH} and the C_{IDI} in B10. Nickel exceeded the C_{LEACH} in Boring B2, and both the C_{LEACH} and the C_{IDI} in B10. Boring B6 contained PCBs above the C_{IDI}. No C_{LEACH} is available for PCBs; the C_{IDI} is considered to be protective of leaching to groundwater.

Figure H1. Plate-n-Stuff Site Map

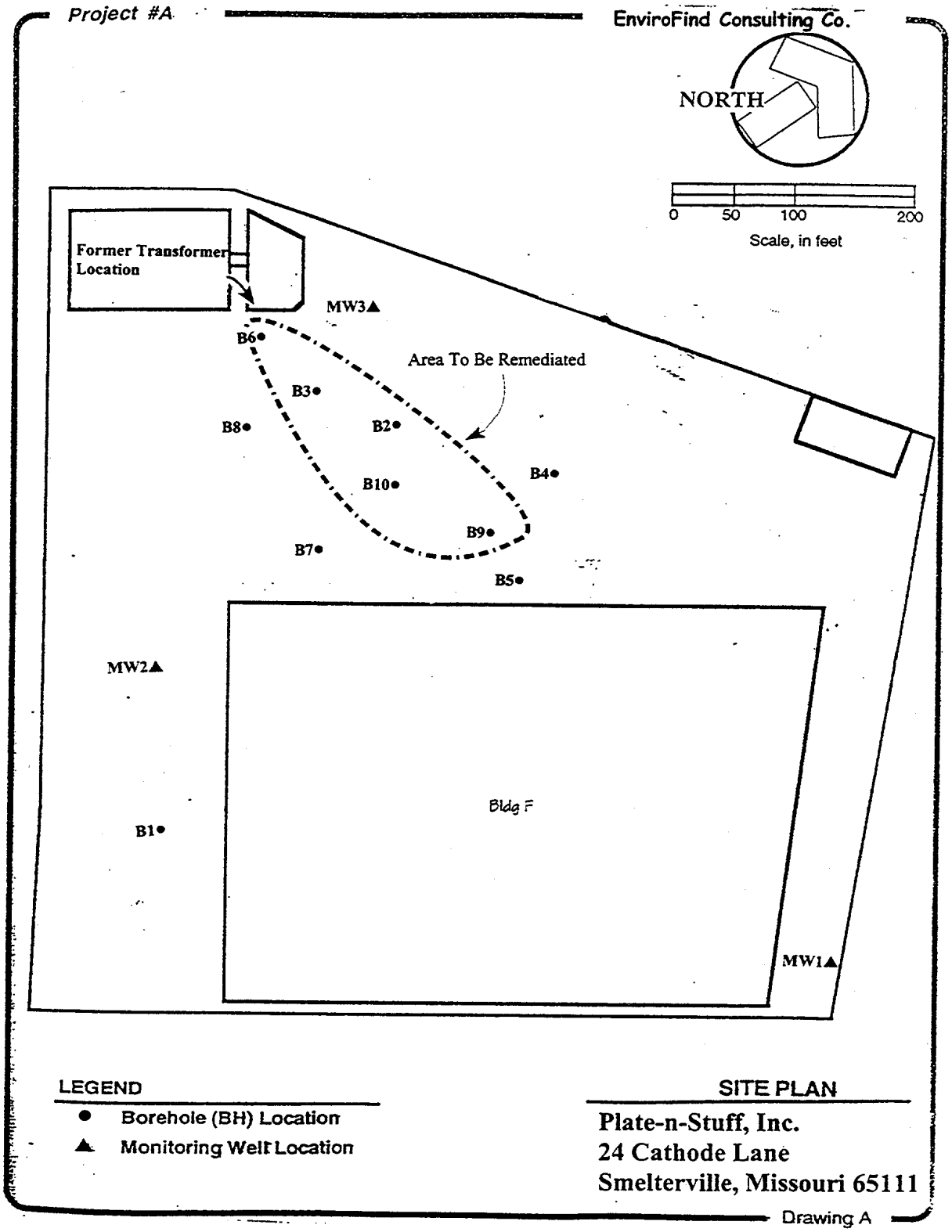

Table H1. Comparison of Plate-n-Stuff Soil Contaminant Levels to Cleanup Targets

Contaminant	Site Soil Contaminant Levels (mg/kg)[1]					CALM Cleanup Targets (mg/kg)	
	B2 2-3ft	B3 1-2ft	B6 2-3ft	B9 1-2ft	B10 2-3ft	Scenario A STARC	C_{LEACH}
Cadmium	**110**	**24**	8	**91**	**250**	87	11
Chromium	**720**	**450**	30	**50**	**2800**	1300	38
Nickel	**350**	110	125	140	**7250**	4780	170
PCBs	0.05	0.3	**71**	0.08	0.4	0.6	NA

1. Results of soil boring analyses. Depth intervals indicated below boring number. Only those boring samples found to contain contamination are included. Sample results which are above the CALM cleanup targets are shaded. See Figure H1 for map of boring locations.

Results from sampling of the monitoring wells were compared to the Tier 1 groundwater target concentrations in Table B1, Appendix B, as shown in Table H2. Cadmium and nickel were detected in the groundwater in all three monitoring wells at concentrations below their respective cleanup targets. Based on the sampling data, it was determined that soil contamination had not significantly affected groundwater at the site.

Table H2. Comparison of Plate-n-Stuff Groundwater Contaminant Levels to Cleanup Targets

Contaminant	**Site Groundwater Contaminant Levels (ug/l)**			**CALM Cleanup Targets (ug/l)**
	MW1	**MW2**	**MW3**	**GTARC**
Cadmium	**0.1**	**0.9**	**3.8**	**5**
Nickel	**27**	**12**	**59**	**100**

Based on this comparison, it was determined that the Tier 1 soil cleanup levels were exceeded at boring locations B2, B3, B6, B9, and B10. The user proceeded to the Tier 1 Decision Point (Section 3.4 of the guidance document), and evaluated the options. Due to time constraints involved in the scheduling of redevelopment activities, and considering the limited extent of soil contamination, the property owner decided not to spend the additional time and money required to assess the site under a Tier 2 evaluation. The limitations on land use that would be required with the use of any engineering or institutional controls was not acceptable to the developer. Therefore the participant chose to propose a remedial action plan addressing the cleanup of contam-

inated soils at the site to achieve the Tier 1 soil target concentrations in Table H1.

2.4 Remediation

Various remediation techniques were evaluated. Due to time constraints, excavation and removal of contaminated soils to an approved off-site disposal facility was selected from among the remediation options. A remedial action plan (RAP) was prepared and submitted to VCP for review. The plan outlined a general approach for confirmation sampling to verify that cleanup levels were achieved. Since the participant proposed to clean the site up to Tier 1 Scenario A cleanup targets, no public participation was required.

The department reviewed and approved the RAP, and the plan was implemented. VCP staff were present on-site to observe remediation activities, and provide guidance on where to locate confirmation sampling points. Confirmation sampling in accordance with the approved RAP demonstrated that cleanup levels had been met.

2.5 Certification of Completion

Upon completion of remediation, the participant submitted a final CALM report, and requested a certificate of completion. The department reviewed the report, and concurred that the cleanup targets had been achieved. A certificate of completion was therefore granted. Since the site was remediated to residential land use cleanup targets, no institutional controls were necessary, and future land use on the property is unrestricted.

3. EXAMPLE SITE B: CHEMWOOD INDUSTRIES

3.1 Background & History

This 5 acre site, located near a major river on the outskirts of a large city, operated as a small wood treatment facility from 1942 to 1970. The property had been idle since 1970 due to the perceived potential for environmental contamination. Interest developed in using the site as a storage and transfer facility using the access from an adjacent railroad spur and the river. The owner enrolled the property into the VCP to investigate the perceived contamination, and if necessary, to remediate the site in order to obtain a certificate of completion. Several potential developers of the site have expressed interest in purchasing the facility under the condition that a DNR certificate of completion accompanies the property.

3.2 Environmental Conditions

Phase I and Phase II environmental assessments identified the presence of soil and groundwater contamination. Contaminants detected at the site are those used in wood preservation, including pentachlorophenol and chromium. Two areas of concern were

identified based on past operational practices, and on results of the soil sampling (the former storage area, and the former sludge field). A map of the site indicating these areas of concern is provided in Figure H2.

The site is fairly level with a slight slope to the northeast toward the river. Depth to bedrock at the site varies from 50-70 feet below ground surface. The subsurface material consists of fine grained silts and clays nearer the surface, grading to coarse sand and gravel near bedrock. Based on regional geologic information, bedrock beneath the site consists of competent dolomitic limestone overlain by a dense layer of chert. Monitoring well data collected as part of the site assessment/characterization indicates that the groundwater surface occurs approximately 30-35 feet below ground surface near the transition from silty clay to fine grained sand. The groundwater gradient is to the northeast, toward the river.

3.3 CALM Evaluation

Upon entry of the site into the Voluntary Cleanup Program, the past environmental assessment reports were submitted to the department for review. The VCP worked with the participant to develop a plan to more completely characterize the vertical and horizontal extent of soil contamination in the two identified areas of concern, and to investigate potential impact to groundwater. Additional soil borings were conducted, and three monitoring wells were installed. The soil boring and monitoring well locations are shown on the site map in Figure H2. Based on the results of this additional investigation, the site was determined to be adequately characterized.

The planned future use of the property as a storage and transfer facility qualified the site for the Scenario C, or industrial land use classification. Therefore, the soil and groundwater contaminant levels at the site were compared to the Scenario C STARC and the GTARC cleanup target concentrations in Table B1of CALM. This comparison is shown in Tables H3 and H4 below. Chromium exceeded the C_{IDI} in boring SB10, and the C_{LEACH} in borings SB3, SB8, SB10, and SB11. Pentachlorophenol exceeded the C_{IDI} in boring SB10, and the C_{LEACH} in borings SB4, SB10, SB11, and SB17.

Table H3. Comparison of ChemWood Contaminant Levels to Cleanup Targets

Contaminant	Site Soil Contaminant Levels (mg/kg)[1]						CALM STARC Levels (mg/kg)	
	SB3 2-3ft	SB4 3-4ft	SB8 1-2ft	SB10 8-10ft	SB11 10-12ft	SB17 2-3ft	Scenario C C_{IDI}	C_{LEACH}
Chromium	**400**	55	**500**	**7500**	**2000**	17	2700	360
Pentachlorophenol	4.3	**16**	6.5	**350**	**20**	**12**	22	7.4

1. Results of soil boring analyses. Depth intervals indicated below boring number. Only those boring samples found to contain contamination are included here. Sample results which are above the CALM cleanup targets are shaded. See figure H2 for map of boring locations.

Figure H2. ChemWood Site Map

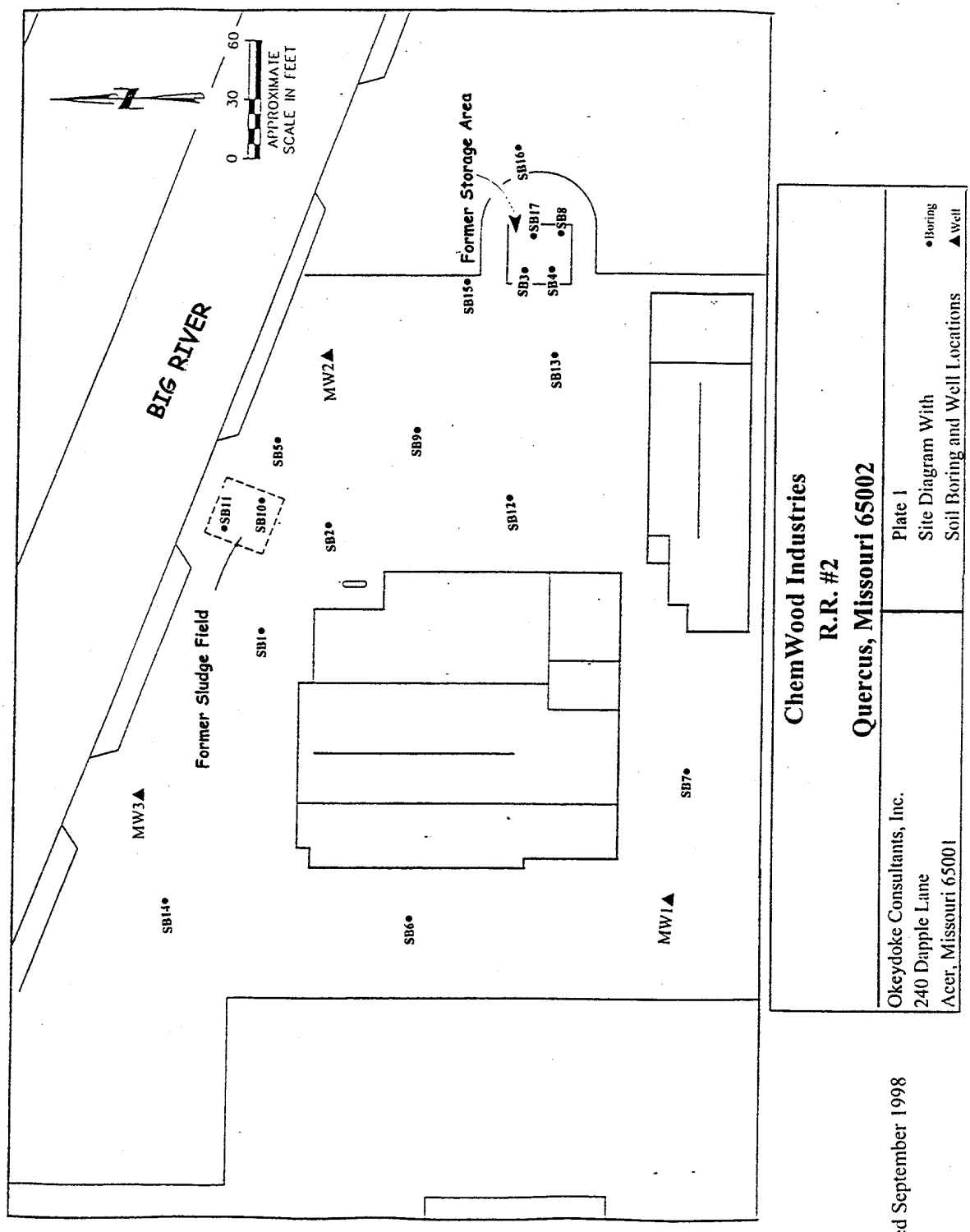

Table H4. Comparison of Chem Wood Groundwater Contaminant Levels to Cleanup Targets

Contaminant	Site Groundwater Contaminant Levels (ug/l)			CALM Cleanup Targets (ug/l)
	MW1	MW2	MW3	GTARC
Chromium	40	66	27	100
Pentachlorophenol	0.3	0.8	0.4	1.0

Results from sampling of the monitoring wells indicate that chromium and pentachlorophenol were detected in the groundwater in all three monitoring wells at concentrations below their respective cleanup targets (GTARCs). Based on the sampling data, it was determined that soil contamination had not yet significantly impacted groundwater at the site.

The participant considered whether to propose a cleanup plan to address both the former storage and sludge field areas, or to conduct further tier evaluation. Most of the exceedences occurred as a result of comparison of soil contaminant levels to the C_{LEACH} target concentrations. The participant decided to more closely examine the assumptions and default values used to calculate the Tier 1 C_{LEACH} values under a Tier 2 assessment, in order to evaluate how accurately they reflect the actual leaching potential of the contaminated soils. The department was notified of the intent to proceed to Tier 2, and the participant collected the additional site characterization data required to replace some of the Tier 1 default assumptions with site-specific data. The specific C_{LEACH} parameters whose defaults were substituted with site-specific data are shown in Table H5 below.

Table H5. Modifications to Tier 1 Formula Default Values

Parameter Used in Calculation of C_{LEACH}	Tier 1 Default value	Site-Specific Value
Aquifer thickness, d_a (m)	NA[2]	30
Dilution factor, DF[1]	20	30
Groundwater hydraulic gradient, dh/dx (m/m)	NA[2]	0.01
Fraction of organic carbon in soil, f_{oc}	0.006	0.02
Hydraulic conductivity, K (m/yr)	NA[2]	31.5
Length of contaminant souce parallel to groundwater flow, L (m)	NA[2]	100
Soil bulk density, $_b$ (kg/L)	1.5	1.65

1. Dilution factor (DF) is a calculated value using several formula variables. See Appendix A for formula used.
2. This parameter is included in the formula used to calculate the dilution factor (DF). No default value is used for this parameter at Tier 1. Instead, a default value of 20 is used for the overall DF, as described in Appendix B.

C_{LEACH} Formulas

$$C_{leach} = C_w\left[Kd + \frac{\theta_w + \theta_a * H'}{\rho_b}\right] \qquad Cw = DF*GTARC \qquad DF = 1 + \frac{K * \frac{dh}{dx} * d}{I * L}$$

$$d = \sqrt{0.0112 * L^2} + d_a\left\{1 - \exp\left[\frac{-L * I}{K * \frac{dh}{dx} * d_a}\right]\right\}$$

The data collected on-site were used in the C_{LEACH} formulas found in Appendix to calculate a site-specific C_{LEACH} cleanup target concentration for chromium and pentachlorophenol. The Tier 2 C_{LEACH} target concentrations for chromium and pentachlorophenol rose approximately 52 % and 413% respectively as compared to the Tier 1 C_{LEACH} values. The proposed Tier 2 C_{LEACH} values were submitted to the department. The VCP confirmed the calculations, and approved the new C_{LEACH} values.

Soil boring sample results were then compared to the new site-specific C_{LEACH} soil targets as shown in Table H6. Under the Tier 2 analysis, due to the change in C_{LEACH}, soil in boring locations SB3, SB4, SB8, and SB17 no longer exceeded the STARC values. However, the samples from boring locations SB10 and SB11 still exceeded the cleanup target concentrations. As a result, contamination in the former storage area was determined to be below cleanup targets, and did not require remediation. However, soil contaminant levels in the former sludge field still exceeded the cleanup criteria.

Table H6. Comparison of ChemWood Contaminant Levels to Tier 2 C_{LEACH}

Contaminant	Site Soil Contaminant Levels (mg/kg)						CALM Cleanup Targets	
	SB3 2-3ft	SB4 3-4ft	SB8 1-2ft	SB10 8-10ft	SB11 10-12ft	SB17 2-3ft	Scenario C STARC	Site-Specific C_{LEACH}
Chromium	400	55	500	7500	2000	17	2700	550
Pentachlorophenol	4.3	16	6.5	350	20	12	22	38

3.4 Remediation

The participant proposed a remedial action plan to address cleanup of the former sludge field area. The RAP was prepared and submitted to the department for review. Concurrently, a

public participation plan was prepared outlining the placement of an advertisement in the local newspaper.

The limited areal extent of contamination, and the time advantages, made excavation and off-site disposal the most cost effective option. Public comment received in response to the newspaper advertisement was adequately responded to by the participant, and resulted in no changes in the RAP. The RAP was approved by the department, and implemented by the participant.

After remedial actions were taken, confirmation sampling was conducted which verified that contaminant levels remaining on the site were below the approved cleanup targets.

3.5 Certification of Completion

The participant submitted a final CALM report, and the department concurred with the determination that the site had been cleaned up to the approved target concentrations. Since land use scenario C cleanup targets were used, institutional controls were required in order to ensure that the future land use scenario did not change. A restrictive covenant was signed by the participant to limit current and future use of the property to industrial applications, and allow the department access to the site in order to conduct periodic inspections to verify that the land uses remain appropriate. The restrictive covenant was recorded in the County Recorder's office, and placed in the property chain of title along with the certificate of completion. Additionally, a contract was signed with DNR in which the participant agreed to submit a one-time monitoring fee to cover the costs of future department inspections.

4. EXAMPLE SITE C: BARREL BUSTERS CO.

4.1 Background & History

This site operated as a drum reclaiming and reconditioning facility from the early 1950s to 1973 when the company went bankrupt and abandoned the property. The company received used drums for cleaning and then re-sold the reconditioned drums. Facilities at the site included an incinerator used to burn residual drum contents, an unlined earthen-bermed lagoon in which drum rinsate was collected, and storage areas for incoming and reconditioned drums. The company is believed to have disposed of crushed and possibly partially full drums in the lagoon when it was drained and backfilled just prior to abandonment of the property.

Ownership of the property reverted to the local municipality through non-payment of property taxes. In response to a citizen complaint in 1984, the site was listed on EPA's CERCLIS, however a complete investigation and assessment was not done. Although the property is located in what is now a very desirable commercial/light industrial land use location, inclusion on CERCLIS and the history of operations at the site helped to stigmatize the property, and it has remained vacant since foreclosure.

Financial incentives available through the Department of Economic Development's new Brownfield Redevelopment Program (BRP) helped attract MegaSoft, a local computer software corporation seeking to expand their technical support center. The site applied for and was accepted into the BRP and the VCP programs simultaneously.

4.2 Environmental Conditions

MegaSoft initiated an environmental assessment as part of performing due diligence in preparation for purchasing the property from the municipality. Soil and groundwater sampling was conducted in the areas of concern identified during the assessment of past operations.

The surface elevation of the site is fairly level, and soils consist of silty clays from 0-30 feet below ground surface (bgs) where a low permeability 50 feet thick shale layer is ncountered. Beginning about 15 feet bgs, the silty clay is interspersed with sand seams and lenses, grading to medium to coarse sand toward the shale surface. Groundwater occurs approximately 10-12 feet bgs, and flows to the north.

Soil and groundwater contamination was identified in the area surrounding the former lagoon. An additional round of soil and groundwater sampling was conducted to better define the vertical and horizontal extent of contamination, and to collect site-specific hydrogeologic data for use in Tier 3 assessment. Crushed empty and partially full drums were encountered in the lagoon backfill during the investigation.

Based on the data collected, a groundwater contaminant plume originating directly below the lagoon extends downgradient to the north. The plume has not traveled off-site, and ends somewhere between 300 feet north of the lagoon and the northern property boundary. Soil and groundwater contamination exceeded the Tier 1 cleanup levels beneath the former lagoon bottom, and in the subsurface radiating away from the lagoon perimeter.

4.3 CALM Evaluation

Based on the hydrogeological conditions of the site, its location, and other parameters, the participant felt that the assumptions in the Tier 1 equations were not representative of site conditions. The department concurred, and the use of Tier 3 for determination of cleanup standards was approved. Alternate modeling approaches were used to simulate leaching and groundwater transport to help develop site-specific cleanup targets.

Trichloroethene, benzene, and toxaphene were detected above the CALM Table B1 STARC levels in several borings across the site (Table H8). Arsenic was also detected above the STARC levels, however is was believed to reflect natural background concen-trations rather than site contaminantion as discussed below. But when compared to the site-specific STARC values, only soil from boring locations nearest the lagoon (SB-5 and SB-6) exceeded cleanup levels.

Trichloroethene and benzene were detected at concentration slightly above the Tier1/2 GTARC in several monitoring well locations (Table H8). The contaminant plume was found not to be moving off site. The participant used the contaminant fate and transport models SESOIL and MODFLOW/MOC to predict soil and groundwater contaminant migration. The models provided estimates of groundwater contaminant levels which could be allowed to remain in place without resulting in movement off-site at levels exceeding the Tier 1/2 GTARCs. The modeled Tier 3 C_{LEACH} and GTARCs are shown in Tables H7 and H8. The modeling suggested that the probability of off site contaminant migration is very low due to sorption, dilution, and degradation. The results also suggested that vertical migration to the lower limestone high-yield aquifer is severely limited by the thick shale layer present.Drinking water for the surrounding area is believed to come primarily from surface sources. A well survey indicated that no residential wells are present within 1 mile of the site.

Although several soil samples contained arsenic slightly above the STARC level, the participant suspected that this was a reflection of natural background levels rather than site contamination. A sampling plan was prepared outlining the collection and statistical comparison of background arsenic concentrations in surrounding native soils to levels found during the investigation. The results of this comparison showed that the differences between arsenic concentrations detected at the site and mean background concentrations of arsenic in the native soils were not statistically significant (Table H7).

Table H7. Comparison of Barrel Busters Soil Levels to Tier 3 Cleanup Targets

Contaminant	Site Soil Contaminant Levels (mg/kg)[1]							CALM Cleanup Targets (mg/kg)			
	SB1	SB2	SB3	SB3	SB4	SB5	SB6	Scen-ario C STARC	Tier1/2 C_{LEACH}	Back-ground mean	Model-ed C_{LEACH}
Benzene	.22	.18	.011	.044	.33	32	15	16	0.057	ND	0.35
Trichloroethene	1.13	.044	ND	.020	0.66	112	53	81	0.097	ND	1.2
Arsenic	12	17	16	15	14	10	16	14	29	17	48
Toxaphene	1.4	2.1	0.6	0.05	0.1	94	50	2.3	35.3	ND	51

1. Results of soil boring analyses. Only those boring samples found to contain contamination are included here. Sample results which are above the CALM cleanup targets are shaded.

Table H8. Comparison of Barrel Busters Groundwater Levels to Tier 3 Groundwater Targets

Contaminant	Site Groundwater Contaminant Levels (ug/l)					CALM Cleanup Targets (ug/l)	
	MW1	MW2	MW3	MW4	MW5	Tier 1/2 GTARC	Tier 3 GTARC
Benzene	84	44	3.1	1.8	0.3	5	100
Trichloroethene	27	17	1.4	<0.5	<0.5	5	42
Toxaphene	10	6	1.2	0.05	<0.005	3	27

4.4 Remediation

Based on the modeling results, after removal of the contaminated soil (hot spot removal), the groundwater levels are expected to decrease, possibly below the GTARCs. Since the groundwater contamination is limited to the shallow saturated zone, has not migrated to the deeper limestone aquifer, and based on the modeling results is not anticipated to migrate vertically or horizontally off-site, it was determined that the levels present did not require active remediation. The participant suggested that groundwater contaminants be left in place with a restrictive covenant against use of groundwater at the site, and monitoring requirements for 3 years. If levels are found to decrease below the GTARC, monitoring requirements would be removed, and the restrictive covenant modified. Monitoring will take place at the downgradient property boundary as a point of compliance (POC), and between the source and the POC.

The public participation process outlined in Appendix E was conducted. Concerns were raised during the public availablity session by neighboring residents regarding the potential for odor problems during excavation of the lagoons. The RAP was modified to address this concern and minimize odor release.

The lagoon area was excavated, and confirmation sampling conducted to demonstrate the effectivness of remediation. Permanent monitoring wells were installed where necessary, and the monitoring program was initiated to verify that groundwater contamination does not migrate offsite, and that the groundwater modeling predictions are accurate.

4.5 Certification of Completion

The 3 years of monitoring data adequately supported the model predictions, and confirmed that no off-site contaminant migration occured or will occur. The participant prepared a final CALM report and requested a certificate of completion. A restrictive covenenant and contract were signed, and a restrictive covenent was prepared and entered into the property chain of title.